Dr. Georgios Varnavides

Postdoctoral Research Fellow, Miller Institute for Basic Research in Science, University of California, Berkeley

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Education

Ph.D., Materials Science and Engineering , *Massachusetts Institute of Technology* and *Harvard University*, Cambridge, MA, USA. 2017-2022
- Co-advisors: Prof. P. Narang (Harvard) and Prof. P. Anikeeva (MIT).
- Thesis: *Electron Hydrodynamics in Crystalline Solids*.

B.S., Materials Science and Engineering , *Massachusetts Institute of Technology*, Cambridge, MA, USA. 2013-2017
B.S., Civil and Environmental Engineering , *Massachusetts Institute of Technology*, Cambridge, MA, USA.

Research Interests

- Scanning transmission electron microscopy.
- Functional imaging of charge, heat, and spin using computational imaging methods.
- Spatially-resolved transport of non-equilibrium carriers in materials.
- Materials science pedagogy.

Awards & Honors

Outstanding Ph.D. Thesis Research Award, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*. 2022

Miller Institute Postdoctoral Fellow 2022-2025 (awarded and accepted), *Miller Institute for Basic Research in Science, University of California, Berkeley*

Heising-Simons Postdoctoral Fellow 2022-2024 (awarded), *Kavli Energy NanoScience Institute, University of California, Berkeley*

Kavli Institute at Cornell Postdoctoral Fellow 2022-2024 (awarded), *Kavli Institute at Cornell, Cornell University*

Materials Research Society Graduate Student Gold Award, MRS Fall 2021 Meeting. 2021

John Wulff Award for Excellence in Teaching an Undergraduate Subject, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*.

Hugh Hampton Young Fellow, *Massachusetts Institute of Technology*. 2020

Best Paper Award for Second or First Year Student, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*. 2019

Piper Presidential Graduate Fellow, *Massachusetts Institute of Technology*. 2017

Horace A. Lubin Award for Outstanding Service to the DMSE Community, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*.

Juan Hermosilla Prize for exceptional talent and potential at the intersection of mechanics, materials & structures, *Department of Civil and Environmental Engineering, Massachusetts Institute of Technology*.

Julian Szekely Award for the Outstanding Junior, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*. 2016

Undergraduate Student Teaching Award in Teaching an Undergraduate Subject, *Department of Materials Science and Engineering, Massachusetts Institute of Technology*.

Invited Seminars

Dose-Efficient Single-Particle Analysis: Joint Ptychographic Tomography and Tilt-Corrected Bright Field STEM, Chan Zuckerberg Institute for Advanced Biological Imaging (CZII), *Redwood City, CA, USA*. 2023

Joint Ptychographic Tomography: From Magnetic Vector Potentials to Single Particle Analysis, Rosalind Franklin Insitute (RFI) and Electron Physical Science Imaging Centre (ePSIC), *Harwell, Oxfordshire, UK*.

Inverse Scattering Problems in S/TEM Using Electron Ptychography: From Three-Dimensions to Magnetic Vector Potentials to Biological Samples, University of Vienna, Physics, *Virtual Seminar*.

Atomic Resolution Imaging of Anti-Ferromagnetism Using Electron Ptychography, Korean Insitute of Energy Technology (KENTECH), Institute for Environmental and Climate Technology, *Naju, South Korea*.

Exotic Current Densities and How to (Computationally) Image Them, Massachusetts Institute of Technology (MIT), Materials Science and Engineering, *Boston, MA, USA*.

Electron Hydrodynamics in Crystalline Solids: Spatially-Resolved Transport Framework, University of California Berkeley (UCB), Physics, *Berkeley, CA, USA*. 2022

Electron Hydrodynamics in Crystalline Solids: Experimental Observations and Spatially-Resolved Transport Framework, University of California Los Angeles (UCLA), Physics, *Los Angeles, CA, USA*.

Nanoscale Imaging of Non-uniform Current Densities in Anisotropic Electron Fluids, Lawrence Berkeley National Laboratory (LBNL), Molecular Foundry, *Berkeley, CA, USA*.

Electron Hydrodynamics in Crystalline Solids: Microscopic Origins, Mesoscopic Size Effects, and Macroscopic Observables, Max Planck Institute (MPI), Chemical Physics of Solids, *Virtual Seminar*.

Electron Hydrodynamics in Crystalline Solids: Microscopic Origins, Mesoscopic Size Effects, and Macroscopic Observables, Northwestern University (NU), Materials Science and Engineering, *Evanston, IL, USA*.

Imaging anisotropic electron fluids with high spatial resolution, Cornell University, Kavli Institute at Cornell, *Virtual Seminar*. 2021

Publications

*For a complete list of publications, please see my Google Scholar profile. *Denotes equal contribution.*

In Preparation

1. G. Varnavides, S.M. Ribet, R. Yalisove, J.E. Moore, C. Ophus, M.C. Scott, Atomic Resolution Imaging of Anti-Ferromagnetism Using Electron Ptychography.

2. G. Varnavides, A.S. Jermyn, P. Anikeeva, P. Narang, SpaRTaNS: Spatially Resolved Transport of Nonequilibrium Species.

Prepress

3. G. Varnavides*, S.M. Ribet*, S.E. Zeltmann, Y. Yu, B.H. Savitzky, V.P. Dravid, M.C. Scott, C. Ophus, Iterative Phase Retrieval Algorithms for Scanning Transmission Electron Microscopy, *arXiv:2309.05250* (2023), **Submitted**.

4. G. Varnavides*, A.S. Jermyn*, P. Anikeeva, P. Narang, Probing carrier interactions using electron hydrodynamics, *arXiv:2204.06004* (2022), **Submitted**.

Journal articles

5. G. Varnavides, A. Yacoby, C. Felser, P. Narang, Charge Transport and Hydrodynamics in Materials, *Nat Rev Mater 8, 726-741* (2023). 2023

6. R.A. Kowalski, J.R. Nolen, **G. Varnavides**, S.M. Silva, J.E. Allen, C.J. Ciccarino, D.M. Juraschek, S. Law, P. Narang, J.D. Caldwell, Mid- to Far-Infrared Anisotropic Dielectric Function of HfS2 and HfSe2, *Adv Optical Mater 10, 2200933* (2022). 2022

7. Y. Wang*, **G. Varnavides***, P. Anikeeva, J. Gooth, C. Felser, P. Narang, Generalized design principles for hydrodynamic electron transpor in anisotropic metals, *Phys Rev Materials 6, 083802* (2022).

8. L. Y. Maeng, D. Rosenfeld, G. J. Simandl, F. Koehler, A. W. Senko, J. Moon, **G. Varnavides**, M. F. Murillo, A. E. Reimer, A. Wald, P. Anikeeva, A. S. Widge, Probing Neuro-Endocrine Interactions Through Wireless Magnetothermal Stimulation of Peripheral Organs, *Frontiers in Neuroscience, 949* (2022).

9. G. Varnavides*, Y. Wang*, P. J.W. Moll, P. Anikeeva, P. Narang, Mesoscopic finite-size effects of unconventional electron transport in PdCoO2, *Phys Rev Materials, 6, 045002* (2022).

10. C. A. Garcia, D. M. Nenno, **G. Varnavides**, P. Narang, Anisotropic phonon-mediated electronic transport in chiral Weyl semimetals, *Phys Rev Materials, 5, L091202* (2021). 2021

11. U. Vool*, A. Hamo*, **G. Varnavides***, Y. Wang*, T. X. Zhou, N. Kumar, Y. Dovzhenko, Z. Qiu, C. A. Garcia, A. T. Pierce, J. Gooth, P. Anikeeva, C. Felser, P. Narang, A. Yacoby, Imaging phonon-mediated hydrodynamic flow in WTe2, *Nat Phys, 1745-2481* (2021).

12. X. Tian*, X. Yan*, **G. Varnavides***, Y. Yuan, D. S. Kim, C. J. Ciccarino, P. Anikeeva, M.-Y. Li, L.-J. Li, P. Narang, X. Pan, J. Miao, Capturing 3D atomic defects and phonon localization at the 2D heterostructure interface, *Sci Adv, 7: eabi6699* (2021).

13. M. R. van Delft, Y. Wang, C. Putzke, J. Oswald, **G. Varnavides**, C. A. C. Garcia, C. Guo, H. Schmid, V. Suss, H. Borrmann, J. Diaz, Y. Sun, C. Felser, B. Gotsmann, P. Narang, P. J.W. Moll, Sondheimer oscillations as a probe of non-ohmic flow in WP2 crystals, *Nat Commun 12, 4799* (2021).

14. J. Park*, F. Koehler*, **G. Varnavides**, M.-J. Antonini, and P. Anikeeva , Influence of Magnetic Fields on Electrochemical Reactions of Redox Cofactor Solutions. *Angew. Chem. Int. Ed..* (2021).

15. G. Varnavides, A. Mortensen, W.C. Carter, Simulating Infiltration as a Sequence of Pinning and De-pinning Processes, *Acta Materialia 210, 116831* (2021).

16. K. Reidy*, **G. Varnavides***, J.D. Thomsen, A. Kumar, T. Pham, A. M. Blackburn, P. Anikeeva, P. Narang, J. M. LeBeau, F. M. Ross, Direct imaging and electronic structure modulation of moiré superlattices at the 2D/3D interface, *Nat Commun 12, 1290* (2021).

2020

17. G. Varnavides*, A. S. Jermyn*, P. Anikeeva, P. Narang, Electron hydrodynamics in anisotropic materials, *Nat Commun 11, 4710* (2020).

18. D. Gregurec, A. W. Senko, A. Chuvilin, P. D. Reddy, A. Sankararaman, D. Rosenfeld, P.-H. Chiang, F. Garcia, I. Tefel, **G. Varnavides**, E. Ciocan, P. Anikeeva, Magnetic Vortex Nanodiscs Enable Remote Magnetomechanical Neural Stimulation, *ACS nano 14, 7* (2020).

19. P. Periwal, J. D. Thomsen, K. Reidy, **G. Varnavides**, D. N. Zakharov, L. Gignac, M. C. Reuter, T. J. Booth, S. Hofmann, F. M. Ross, Catalytically mediated epitaxy of 3D semiconductors on van der Waals substrates, *Applied Physics Reviews 7, 031402* (2020).

20. J. Moon, M. G. Christiansen, S. Rao, C. Marcus, D. C. Bono, D. Rosenfeld, D. Gregurec, **G. Varnavides**, P.-H. Chiang, S. Park, P. Anikeeva, Magnetothermal Multiplexing for Selective Remote Control of Cell Signaling, *Advanced Functional Materials 30, 36* (2020).

21. D. Rosenfeld, A. W. Senko, J. Moon, I. Yick, **G. Varnavides**, D. Gregurec, F. Koehler, P.-H. Chiang, M. Christiansen, L. Y. Maeng, A. S. Widge, P. Anikeeva, Transgene-free remote magnetothermal regulation of adrenal hormones, *Science advances 6, 15* (2020).

2019

22. G. Varnavides, A. S. Jermyn, P. Anikeeva, P. Narang, Nonequilibrium phonon transport across nanoscale interfaces, *Phys Rev B, 100, 115402* (2019).

23. S. Rao, R. Chen, A. A. LaRocca, M. G. Christiansen, A. W. Senko, C. H. Shi, P.-H. Chiang, **G. Varnavides**, J. Xue, Y. Zhou, S. Park, R. Ding, J. Moon, G. Feng, P. Anikeeva, Remotely controlled chemomagnetic modulation of targeted neural circuits, *Nat Nanotechnol 14, 967* (2019).

24. M. Kanik*, S. Orguc*, **G. Varnavides**, J. Kim, T. Benavides, D. Gonzalez, T. Akintilo, C. C. Tasan, A. P. Chandrakasan, Y. Fink, P. Anikeeva, Strain-programmable fiber-based artificial muscle, *Science 365, 6449* (2019).

25. J. Vukajlovic-Plestina, W.Kim, L. Ghisalberti, **G. Varnavides**, G. Tutuncuoglu, H. Potts, M. Friedl, L. Guniat, W.C. Carter, V.G. Dubrovskii, A. Fontcuberta i Morral, Fundamental aspects to localize self-catalyzed III-V nanowires on silicon, *Nat Commun 10, 869* (2019).

Conferences

Papers

2023

26. G. Varnavides, S.M. Ribet, R. Yalisove, J.E. Moore, C. Ophus, M.C. Scott, Simultaneous Electrostatic and Magnetic Vector Potential Phase Retrieval Using Electron Ptychography, *Microsc Microanal 29, 278-279* (2023).

27. S.M. Ribet, S.E. Zeltmann, **G. Varnavides**, R. Dos Reis, V.P. Dravid, C. Ophus, Phase Diversity in Ptychographic Reconstructions with a Programmable Phase Plate, *Microsc Microanal 29, 296-297* (2023).

28. B.H. Savitzky, A. Rakowski, A. Bruefach, S.M. Ribet, **G. Varnavides**, S.E. Zeltmann, T. Mishra, M.C. Scott, A.M. Minor, C. Ophus, Architecture, Development Cycle, and Governance Considerations in Co-created Research Sofware: the Example of py4DSTEM and Analysis of 4D-STEM Data, *Microsc Microanal 29, 339-341* (2023).

29. X. Chen, **G. Varnavides**, P. Anikeeva, J. LeBeau, Quantitative Analysis of Correlated Atomic Displacements via Diffuse Electron Scattering, *Microsc Microanal 26, 718-720* (2020). 2020

30. K. Reidy, **G. Varnavides**, J.D. Thomsen, A. Blackburn, T. Pham, A. Kumar, J. LeBeau, F.M. Ross, Forbidden Reflection Moiré Patterns in Metal-2D Material Interfaces, *Microsc Microanal 26, 860-863* (2020).

Presentations

Simultaneous Electrostatic and Magnetic Vector Potential Phase Retrieval Using Electron Ptychography, Microscopy and Microanalysis (M&M) 2023, *Minneapolis, MN, USA*. 2023

Three-Dimensional Imaging of Anti-Ferromagnetism with Atomic Resolution Using Electron Ptychography, International Microscopy Congress (IMC) 2023, *Busan, South Korea*.

Three-Dimensional Inverse Scattering Problems Using Electron Ptychography: Atomic-Scale Imaging of Magnetization and Thermal Diffuse Scattering, Materials Research Society (MRS) Fall 2023, *Boston, MA, USA*.

Investigating the Role of Microscopic Interactions in Electron Hydrodynamics, Materials Research Society (MRS) Spring 2022, *Honolulu, HI, USA*. 2022

SpaRTaNS: Spatially Resolved Transport of Non-equilibrium Species, American Physical Society (APS) March 2022 Meeting, *Chicago, IL, USA*.

Electron Hydrodynamics: Microscopic Origins and Effects of Macroscale Geometries, Materials Research Society (MRS) Spring 2021, *Virtual Conference*. 2021

Electron Hydrodynamics: Microscopic Origins, American Physical Society (APS) March 2021 Meeting, *Virtual Conference*.

Temperature-Resolved Observations and Predictions of Phonon-Mediated Hydrodynamic Flow of Electrons in WTe2, Materials Research Society (MRS) Fall 2020, *Virtual Conference*. 2020

Teaching Materials Science Using the Wolfram Language, Wolfram Technology Conference 2020, *Virtual Conference*.

Crystal Symmetry and Electron Hydrodynamics: A Group Theory Approach, Materials Research Society (MRS) Fall 2019 Meeting, *Boston, MA, USA*. 2019

Spatially-Resolved Non-equilibrium Phonon Transport Across Nanoscale Interfaces, American Physical Society (APS) March Meeting 2019, *Boston, MA, USA*.

Ab initio Predictions of Spatially-Resolved Non-equilibrium 2018

Coherent Transport Phenomena, Materials Research Society (MRS) Fall 2018 Meeting, *Boston, MA, USA*.

Non-Equilibrium Phonon Transport Across Semi-Coherent Interfaces, 16th International Conference on Phonon Scattering in Condensed Matter, *Nanjing, China*.

(De)Generative Art, Wolfram Technology Conference 2017, *Champaign, IL, USA*. 2017

Capillarity in Pressure Infiltration Part I & II: Experiment and Modelling, Materials Science & Technology (MS&T16), *Salt Lake City, UT, USA*. 2016

Posters

Finite-size Effects of Electron Transport in Anisotropic Quasi-Two Dimensional Metals, Materials Research Society (MRS) Fall 2021 Meeting, *Boston, MA, USA*. 2021

Darcy-Brinkman Multiscale Modelling Applied on the Mosul Dam, New England Mechanics 2017 Workshop, *Cambridge, MA, USA*. 2017

Simulating Capillarity in Metal Infiltration, Materials Science & Technology (MS&16), *Salt Lake City, UT, USA*. 2016

Teaching

Lead Instructor

Instructor-G, *Department of Materials Science and Engineering*, Cambridge, MA, USA 2022
- Mathematics and Computational Thinking for Materials Scientists and Engineers I (3.029)

Teaching Assistant

Graduate Teaching Assistant, *Department of Materials Science and Engineering*, Cambridge, MA, USA 2020
- Materials Project Laboratory (3.042)

Undergraduate Teaching Assistant,*Department of Materials Science and Engineering*, Cambridge, MA, USA 2016-2017
- Mathematics for Materials Science and Engineers (3.016)
- Electrical, Optical and Magnetic Properties of Materials (3.024)

Short Courses

Generative Art Workshop, 4-day IAP workshop, *Massachusetts Institute of Technology*, Cambridge, MA, USA. 2017-2022
Co-taught with Emma Vargo, Amina Matt, Jovana Andrejevic, and Nina Andrejevic.

Service & Outreach

Teaching multiple short courses to 9th grade Physics and 11th grade Engineering Honors students at the El-Cerrito high school. 2022-present

Graduate Materials Council (GMC) officer on the Departmental Committee on Graduate Studies (DCGS). 2019-2021

Teen Counselor and Teen Advisor for Camp Kesem, a student-run organization helping children through and beyond a parent's cancer. 2015-2021

Memberships

Microscopy Society of America (MSA). 2022-present

Materials Research Society (MRS). 2018-present
American Physical Society (APS).

Tau Beta Pi (ΤΒΠ) - Engineering Honor Society Member. 2017-present
Chi Epsilon (XE) - Civil Engineering Honor Society Member.

Last updated: November 2023